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Exploring the Match Demands of Division I Women's Collegiate Soccer

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Exploring the Match Demands of Division I Women's Collegiate Soccer

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by

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ABSTRACT

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The purpose of this dissertation is to shed light on the physical demands of women's soccer at the NCAA division I college level. Though research does exists describing the physical demands of women's soccer, the vast majority seeks to explain the physical demands association with the professional and international level. This dissertation sought to: 1) examine the physical demands of NCAA division I women's soccer and 2) observe changes in physical demands of two NCAA division I women's soccer players over a four-year career using a case study approach.

Study 1 examined the physical demands of twenty-three athlete from a single NCAA division I team using Global Positioning System devices during four competitive seasons. Total distance, high-speed running distance and sprinting distances were analyzed for comparison against previously established physical demands associated with higher standards of play as well as for positional differences. Differences were found regarding total distance covered between standards of play. However, more pronounced differences were identified between high-speed running activities and standard of play, with higher standards requiring greater demands for high-intensity activities. Additionally, attacking players were demonstrated to cover greater total distance and high-intensity distance compared to the other position groups.

Study 2 was a case study, observing seasonal variation in match physical demands of two high-level collegiate players during their 4-four college careers. Each player was tracked using GPS devices to record total distance, high-speed running distance and sprint distance. Seasonal variation in physical demands were found for each player, however, no consistent trends were found for both players. Interestingly, lower physical demands were identified during each player's final season of play in comparison to all previous seasons, possibly demonstrating an increased tactical awareness resulting in improved playing efficiency. Nevertheless, future examination including additional data such as fitness testing results, tactical formations, and technical skill assessment are warranted.

With little research available detailing the physical demands of women's soccer at the division I collegiate level, our findings will provide further insight into the physical demands required for division I female players. By understanding the specific physical demands associated with competitive matches, as well as various positions, coaches and sports scientists can be equipped with objective data unique to women's college soccer at the NCAA division I level. Our findings will empower practitioners with valuable information necessary to guide more informed decision making with regard to training structure and prescription, to enhance performance and minimize injury risks.

DEDICATION

This dissertation is dedicated to my family, friends, and mentors who have challenged me to strive and provided guidance and unwavering support through this process.

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CHAPTER 1

INTRODUCTION

Although it has been regarded as the world's most popular sport for decades, only recently has soccer begun to grow in popularity in the United States. With its blossoming popularity, participation in soccer has grown exponentially in the last 15-20 years. Such growth has spawned increasing opportunities to play at various levels from youth, to college, then onto professional and, for the most talented, the international level. This review will provide an examination of the physical demands of women's soccer during match play. Of particular interest will be common data collection tools and analysis methods used by sport scientists to objectively quantify the physical demands of the sport. This review will focus on the physical demands and activity profiles of female players at the international, professional, and collegiate level providing a background against which to compare activity profiles of women collegiate soccer players.

Investigations of the physical demands of women's college soccer has a growing interest as the popularity of both soccer and women's sports have increased. However, even with a growing interest in sport science and performance, a thorough understanding of the physical demands on women's' college soccer remains to be extensively explored. Vescovi et al. (2014) were the first to report on the locomotor characteristics of college female soccer matches, and ultimately a better understanding of the developmental spectrum from youth up to the international level. Much of the current literature objectifying activity profiles for soccer has been an investigation of professional and international level players (Bangsbo, 2006; Bradley, 2009; Mohr, 2008). Additionally, there is a disproportionate amount of literature relating to male players in comparison to female players. This is largely due to the cost associated with tracking

and monitoring technology, which is often limited to professional men's teams (Mara et al., 2017). Men's and women's soccer are contested on the same size pitch, with the same number of players even though males and females can differ dramatically with regard to physical performance characteristics. It has been found by Mohr (2008) that men and women at similar standards of play cover similar total match distance, with men performing a greater volume of high-intensity running (HIR) (≥ 15 km/hr) and sprinting (≥ 25 km/hr) (Abt, 2009). However, it has been proposed by Bradley & Vescovi (2015) that adapting velocity thresholds to more appropriately reflect the physical capacities of women's may result in a similar volume of high-speed running (HSR) and sprinting compared to their male counter parts. It has also been found that higher standards of competition require greater volumes of HSR and sprinting compared to lower levels (Vescovi & Favero, 2014; Andersson, 2010). As a result of this, the application of activity profiles describing female players at the professional and international level may vary significantly from women's players at the division I college level. Therefore, the purpose of this study is to provide a more thorough understanding of the activity profiles of women's soccer at the Division I collegiate level. Such information may provide evidence to more specifically target physical training for coaches and sport scientists.

Dissertation Purposes

1. To investigate the physical match demands of NCAA Division I women's soccer players using GPS tracking devices.
2. To examine the physical match demands of NCAA Division I women's soccer players, dependent on and independent of playing position.
3. To examine season variation in the physical demands of two NCAA Division I women's soccer players over a 4-year career.

Operational Definitions

1. Physical demands: the external work performed by players, more specifically, the total distance run as well as distance run at high-intensity and sprinting.
2. Match activities: include the 3 variables being examined; total distance, high-intensity running distance, and sprint distance.
3. Global positioning systems (GPS): a device used to collect and quantify the physical demands of players.
4. Total distance (TD): the total volume (number of meters) players run during match play across all velocity zones.
5. High-intensity running distance (HIR): running distance at or exceeding moderate speeds as designated by author (Most frequently >15 km/h).
6. High-speed running distance (HSR): running distance at or exceeding high-speeds as designated by author (Most frequently >18 km/h).
7. Sprint distance (SPRT): running distance at or exceeding sprint speeds designated by author (Most frequently >25 km/h.
8. Standard of play: standard referred to the level or quality of play, which the international level (national team) as the highest, followed by the professional level (club team), and amateur level (collegiate soccer).

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

Although it has been regarded as the world's most popular sport for decades, only recently has soccer begun to grow in popularity in the United States. With its blossoming popularity, participation in soccer has grown exponentially in the last 15-20 years. Such growth has spawned increasing opportunities to play at various levels from youth, to college, then onto professional and, for the most talented, the international level. This review will provide an examination of the physical demands of women's soccer during match play. Of particular interest will be common data collection tools and analysis methods used by sport scientists to objectively quantify the physical demands of the sport. This review will focus on the physical demands and activity profiles of female players at the international, professional, and collegiate level providing a background against which to compare activity profiles of women collegiate soccer players.

Soccer

Soccer, or football as it is known in most countries throughout the world, is a sport in which two teams compete for 90-minutes, two 45-minute halves with a 15-minute intermission. The game is played on a range of pitch dimensions ranging from 100-110m in length to 64-75m in width (FIFA)**.** Each team is allowed 11 players on the field at any given time, typically consisting of 10 outfield players and 1 designated goal keeper. Outfield players are permitted to use any parts of their body to control and manipulate the ball other than arms and hands. Goalkeepers on the other hand, are permitted to use their hands inside a designated goal keep

area. During the match, teams are permitted to make substitutions at the coach's discretion. Federation of International Football Association (FIFA), which currently stands as the governing body for international and professional soccer, allows for teams to make up to, but not more than, 3 substitutions during a match. Alternatively, in college soccer, the National Collegiate Athletics Association (NCAA) rules permit teams to make an unlimited number of substitutions throughout the match, only restricting the ability of substituted players to re-enter in the first half of play.

Women's Soccer

Extensive research into women's soccer has been scarce in comparison to the men's game (Gabbett & Mulvey, 2010; Krustrup, 2005; Mohr, 2008; Vescovi, 2014), leaving gaps in the literature regarding depth and breadth of information detailing the physical demands in the women's game at different standards of play. More concerning, the studies to date which have been published, included mainly small sample sizes with regard to number of players, number of matches, or both (Datson, 2017; Vescovi, 2014).

Physical Demands

According to Alexander (2014) research on women's college soccer is scarce. At the time of his observation, there was only one other study investigating the activity profiles of women's college soccer players. Although there has been literature detailing physical demands of women's soccer at the professional and international levels (Andersson et al., 2010, Mohr et al., 2008), considering that high-speed running and sprinting efforts, as well as distance covered, increase with the standard of play, it can be hypothesized that the activity profiles of women's

college soccer deviate from those found at the professional and international standard of play. More recently, Curtis et al. (2018) investigated men's college soccer players and found, on average, players covered a total distance of 8,900–9,900m per match with 1,300–1,900m of those at high-speed. Upon comparison, this is less than the data reported by Bradley et al., (2010) for professional players which average 10–14 km of total distance (Bangsbo, 2006) and 2,700 m of high-speed distance (Bradley, 2010). These findings support the previous literature (Mohr, 2008) in that higher standards of play require greater physical outputs regarding total distance covered, high-speed distance and sprint distance. This is in alignment with the findings of Alexander (2014) who determined that the physical demand of the game differs based on, among other things, playing position, team tactics, level of competition, and gender. Therefore, with little evidence existing to detail the physical demands of women's soccer at the collegiate level, further investigation into this specific area of research is needed.

Global Positioning Systems (GPS)

For decades, coaches and sport scientists have sought a better understanding of the physical demands of soccer match play. Generally speaking, understanding the specific requirements of matches at various levels of play provides sport scientists with the specific information necessary to more appropriately prepare athletes to meet the unique demands of their sport, level of competition, and playing position. Traditionally, this has been accomplished using time-motion analysis. Time-motion analysis consists of numerous video cameras being strategically placed around the pitch to capture match activities from multiple angles. Following the match, videos were analyzed using computer coding to provide an overview of the physical work performed during the match. Though video analysis is still utilized by many clubs

throughout the world, the development and advancement of player mounted Global Positioning Systems (GPS) has become increasingly popular. According to Dwyer and Gabbett (2012) the development and application of GPS technology to the sporting environment has circumvented video time-motion analysis in large part due to the more time efficient collection and analysis process as well as the greater validity and reliability. Supporting Dwyer and Gabbett's (2012) assertion, Randers et al. (2010) compared GPS and time-motion analysis. Randers (2010) compared common video-based time-motion analysis techniques used for analysis of elite women's soccer (Andersson et al., 2010; Gabbett and Mulvey, 2008; Krustrup et al., 2005; Krustrup et al., 2010; Mohr et al., 2008; Randers, et al., 2010) and a GPS device sampling at 5 Hz. The research reported a meaningful difference between GPS and video analysis in total distance covered and the amount of distance covered at high-intensity velocities, 13% and 23% respectively (Hewitt et al., 2014; Randers et al., 2010). Therefore, it may be difficult to accurately compare the findings of studies using differing data collection and analysis methods.

Although an in-depth overview of GPS player tracking is beyond the scope of our investigation, a summary will be provided. Originally developed for military use, Cummins (2013) succinctly describes Global positioning system (GPS) as "a satellite-based navigational technology capable of providing coaches and sports scientists with comprehensive analysis of player performance during training and match play" (Cummins, 2013). Since being introduced into the sports arena, GPS has repeatedly proven to be a valid and reliable tool for measurement of distance and velocity, with higher sampling frequencies offering increased validity and reliability (Aughey et al., 2010; Cummins, 2013; Johnson et al., 2012; Waldron, 2011; Varley, 2012). Through the measurement of player movements, GPS allows sport scientists to objectively quantify physical demands placed on the athletes, examine match performances,

differentiate positional workloads, monitor training volumes and intensities, and manage changes in player/team workloads (Dwyer and Gabbett, 2010; Cummins, 2013; McLellan et al., 2011). More specifically, GPS technology measures and quantifies efforts and distances at various speeds with the classification of movement into distinct velocity zones. Standard classifications include standing, walking, jogging (low-speed), running (moderate-speed), high-speed running, sprinting, and maximal speed (Dwyer & Gabbett, 2010; McLellan, 2011; Cummins, 2013). Often, these activities are categorized into low-intensity running, low-speed running and slower, and high-intensity running, moderate-speed running and faster (Andersson, 2010; Mohr, 2008; Vescovi, 2014). However, little uniformity exists regarding velocity thresholds used for high-speed running, making comparison within and between sports problematic (Cummins, 2013; Dwyer and Gabbett, 2010).

Match Activities. In our examination of the literature, we will focus our attention on variables which objectify the physical demands of soccer match play, specifically total distance covered, high-intensity distance and sprint distance. In doing so, we narrow our investigation to the most pertinent variables affecting match outcomes as well as those which are most easily understood by coaches and commonly explored by researchers. Within the current literature, there exists ample support for our focus on total distance, high-intensity running distance and sprint distance. Quantifying total distance provides an estimate of total volume, additionally, it has historically been one of the most common variables studied (Cummins, 2013). According to Bangsbo (2014), although the majority of distance is covered at low-speeds, periods of high intensity running are crucial to the outcomes of football matches by directly impacting goal-scoring opportunities (Datson, 2017). Additionally, the amount of high-speed running

distinguishes top-class players from those at lower levels (Hewitt et al., 2014; Krustrup et al., 2005; Reilly et al., 2000), with top-class players covered 28% and 58% more high-speed running and sprint distances respectively (Mohr, 2003).

Standards of Play

During a 90-minute match, women's soccer players across varying standards of play have been found to cover total distances ranging from approximately 9,000m – 12,000m (Krustrup et al., 2005; Mohr et al., 2008; Gabbett & Mulvey, 2008; Andersson et al., 2010; Randers et al., 2010; Hewitt, 2014). Factors such as standard of play, tactical formation, position, match importance, field size, field condition, and weather, among other things, are likely to impact the physical outputs during a match. Additionally, it has been found by Mohr et al. (2008) that physical demands of match play vary according to the standard of competition and playing position, with higher standards requiring more significant physical outputs, specifically with regard to high-intensity running distance and sprint distance (Figure 1.1 and 1.2).

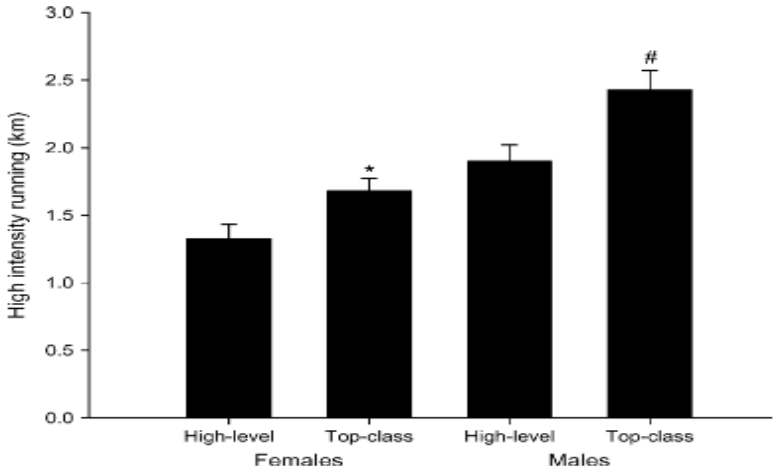

Figure 1.1. High intensity running by standard of play and sex (Mohr et al., 2008).

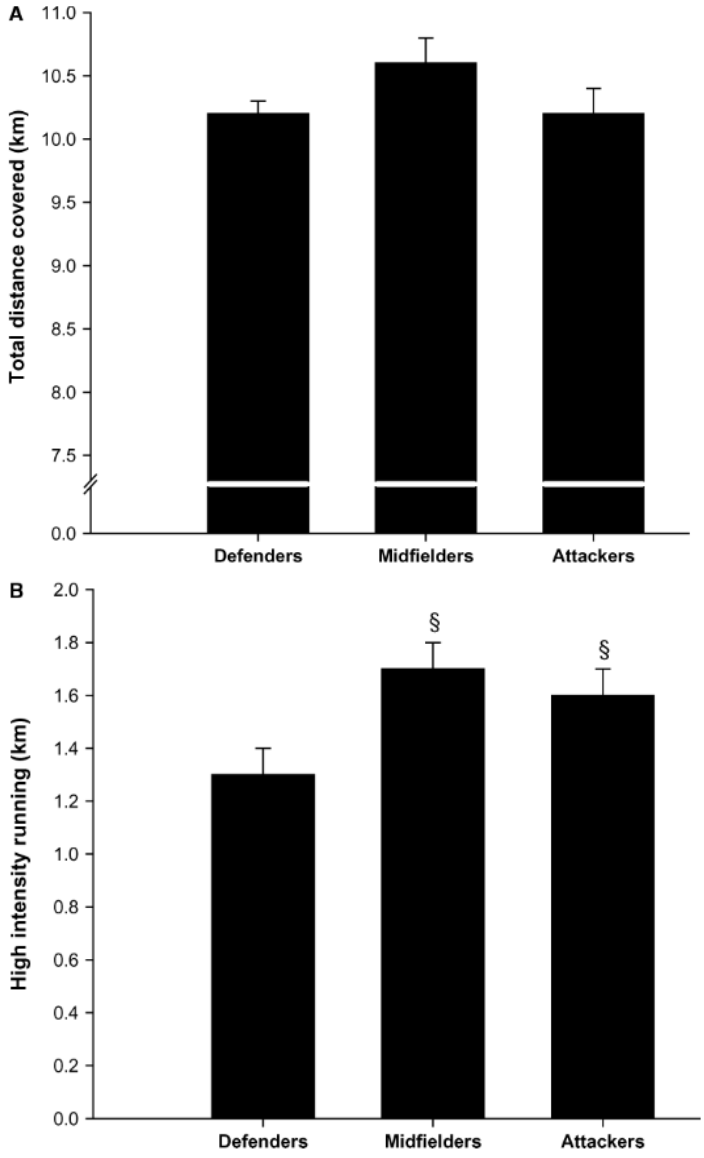

Figure 1.2. Total distance & High intensity distance covered by position (Mohr et al., 2008).

International Level. International level soccer represents the highest standard of play achievable in men's or women's soccer. Mohr et al. (2008) examined the activity profiles of women's soccer players at the international level. A sample of 19 international players from 9 different countries were videotaped using multiple cameras, strategically positioned around the

pitch. Players were recorded in one or two matches. Following the match, player videos were replayed for analysis with using computerized coding of activity patterns (Bangsbo, 1991; Bangsbo, 1994, Krustrup, 2001; Krustrup, 2006; Mohr, 2003). In their analysis, Mohr (2008) determined international players ran an average of 10,330m per match with approximately 1,680m being performed at high intensity (>15 km/h) and 460m of sprint distance (>25 km/h). Regarding positions specific match demands, Mohr and colleagues found little difference between playing position for total distances covered. However, midfield players accumulated the greatest volume of high-intensity distance 1,650m when compared to attackers (1,630m) and defenders (1,260m) as can be seen in figure 2. Attackers (520m) on the other hand, sprinted more than midfielders (430m) and defenders (330m) as can be seen in figure 3. Alternatively, in a study conducted by Hewitt et al., (2014), which observed 15 Australian international players for 13 matches using player mounted GPS units (Catapult Sports, Melbourne, Australia) sampling at 5 Hz, international players covered less total distance, 9,631m, as well as a lower range of distances across positions with forwards covering 9,442m, midfielders covering 10,150m and defenders covering 8,759m compared to the finding of Mohr (2008). It was also found that Australian international players averaged 2,407m of high-intensity distance during match play, which Hewitt defined as running at velocities > 12 km/h while sprint distances (> 19 km/h) were 338m. In line with the total distance covered by position, midfield players accumulated the greatest volume of high-intensity running distance and sprint distance, 2,797m and 392m respectively, compared to both attackers (2,272m and 388m) and defenders (1,744m and 188m).

In another analysis, Datson et al. (2017) used a computerized semiautomated multicamera image recognition system (Prozone Sports Ltd., Leeds, United Kingdom) to analyze the activity profiles of 107 outfield players during international competition, compiling 148

individual match observations derived from 10 matches featuring 13 teams. Players observed were categorized into 5 playing positions: central and wide defenders, central and wide midfielders, and attackers. Consistent with Prozone's standardized velocity thresholds, high-speed running threshold was set at 19.8–25.1 km/h and sprinting threshold was established as > 25.1 km/h. Interestingly, the authors further classified activity profiles using total high-intensity running, which was determined as total distance covered at velocities > 14.4 km/h as well as total very high-speed running or total distances covered at velocities > 19.8 km/h. During international competition, it was determined that European players covered 10,321m of total distance over the course of a 90-minute match. Mean high-speed running and sprint distance across all positions was 608m and 168m, respectively, while total high-intensity running distance was found to be 2,520m and very high-speed running distance of 776m. As for specific demands of the 5 playing positions (Table 1.1), central midfield players covered the most total distance

Table 1.1

Influence of playing position on match physical activity profiles (modified from Datson, 2017)

	CD	WD	CM	WM	A	All positions	*p*
TD (m)	9,489 ± 562§$^{3-5}$	10,250 ± 661‖^{3}¶^{3}	10,985 ± 706‖^{5}#^{3**3}	10,623 ± 665‖^{4}	10,262 ± 798‖^{3}¶^{3}	10,321 ± 859	<0.001
Walking (m)	3,401 ± 142¶^{3}	3,301 ± 190#^{3}	3,224 ± 183‖^{3}#^{3}	3,328 ± 182	3,449 ± 214¶^{3**3}	3,326 ± 194	<0.001
Jogging (m)	4,158 ± 457¶^{4}	4,382 ± 426¶^{3}	4,857 ± 451§$^{3-4}$	4,488 ± 445¶^{3}	4,202 ± 606¶^{3}	4,448 ± 537	<0.001
Running (m)	1,367 ± 193§$^{4-5}$	1,743 ± 293‖^{4}¶^{3}	2,029 ± 310‖^{5}#^{3**3}	1,865 ± 324‖^{4}	1,714 ± 338‖^{4}¶^{3}	1,744 ± 373	<0.001
HSR (m)	423 ± 79§$^{4-5}$	634 ± 168‖^{4}	683 ± 170‖^{5}	700 ± 167‖^{5}	651 ± 135‖^{5}	608 ± 181	<0.001
Sprinting (m)	111 ± 42§$^{3-5}$	163 ± 79‖^{3}	170 ± 69‖^{3}	220 ± 116‖^{3}	221 ± 53‖^{5}	168 ± 82	<0.001
THSR (m)	1,901 ± 268§$^{4-5}$	2,540 ± 500‖^{4}¶^{3}	2,882 ± 500‖^{5**4}	2,785 ± 510‖^{5}	2,586 ± 463‖^{4}	2,520 ± 580	<0.001
TVHSR (m)	534 ± 113§$^{4-5}$	796 ± 237‖^{4}	853 ± 229‖^{4}	920 ± 260‖^{4}	872 ± 161‖^{5}	776 ± 247	<0.001
VHSRP (m)	103 ± 48§$^{4-5}$	309 ± 161‖^{4}#^{4}††^{3}	311 ± 197‖^{4}#^{4}††^{3}	485 ± 195‖^{5}¶^{3**3}	530 ± 127‖^{5}¶^{4**4}	313 ± 210	<0.001
VHSRWP (m)	371 ± 100¶^{3}	418 ± 120#^{3}	485 ± 163‖^{3}#^{4}††^{3}	366 ± 116¶^{3}	274 ± 114¶^{4**3}	399 ± 143	<0.001
Explosive Sprints (%)	53 ± 10	48 ± 9	54 ± 10‡‡^{3}	50 ± 14	48 ± 8	51 ± 10	0.090
Leading Sprints (%)	47 ± 10	52 ± 9	46 ± 10§§^{3}	50 ± 14	52 ± 8	49 ± 10	0.088

*CDs = central defenders; WDs = wide defenders; CMs = central midfielders; WMs = wide midfielders; A = attackers; TD = total distance; HSR = high-speed running; THSR = total high-speed running; TVHSR = total very high-speed running; VHSRP = total very high-speed running with team in possession of the ball; VHSRWP = total very high-speed running without team in possession of the ball (mean ± *SD*).

†Numbers denote magnitude of effect size (ES) for significant differences: 3 = moderate ES (>0.6–1.2), 4 = large ES (>1.2–2.0), and 5 = very large ES (>2.0).

‡Significant difference ($p \leq 0.05$).

§Different from all other playing positions.

‖Different from CD.

¶Different from CM.

#Different from A.

**Different from WD.

††Different from WM.

‡‡Different from percentage of leading sprints.

§§Different from percentage of explosive sprints.

(10,985m) while central defenders covered the least (9,489m). Central defenders also ran far less distance at high-speeds (423m) and sprinting (111m) in comparison to all other positional categories. Wide midfield players had the highest volumes of high intensity work, running 700m at high-speeds and sprinting 220m.

More specifically, Datson et al. (2014) conducted a review of available literature to describe the applied physiology of female soccer (Table 1.2). Based on their findings, outfield players at the international level covered approximately 10,000m of total distance with high-intensity running (>15 km/h) ranging between 1,530-1,680m. Differing physical requirements of various outfield positions were also quantified for total distance, high-speed distance and sprint distance. According to the review central defenders covering a total distance of 9,489m, wide defenders covering 10,250m, central midfielders covering 10,985m, wide midfielders covering 10,623m, and attackers covering 10,262m. Central defenders were also found to cover the least

Table 1.2

Physical demands of match play for elite female soccer players (modified from Datson, 2014)

References	Year	*n*	Competition level	Nationality/ region	Distance covered (km	Number of activity changes	Number of high intensity bouts	High intensity running (km)	High intensity (%)	Sprinting (%)	Sprint distance (m) (>25 km·h^{-1})	Number of sprinting bouts (>25 km·h^{-1})	Method of data capture
Andersson et al. [10]	2010	17	International	Scandinavian	9.9 ± 1.8	1641 ± 41	187 ± 15	1.53 ± 0.1		0.65 ± 0.06	256 ± 57		Video tape
		17	Domestic league	Scandinavian	9.7 ± 1.4	1593 ± 30	168 ± 12	1.33 ± 0.9		0.54 ± 0.05	221 ± 45		Video tape
Andersson et al. [131]	2008	21	Highest division	Swedish	9.9			1.15					Video tape
Gabbett and Mulvey [11]	2008	13	Vs. male youth teams	Australian	9.32 ± 0.84			1.86 ± 0.48[a]					Video tape
		13	National league	Australian	9.70 ± 0.48			2.01 ± 0.30[a]					Video tape
		13	International	Australian	9.97 ± 1.14			2.46 ± 0.49[a]					Video tape
Hewitt et al. [13]	2008	15	International	Australian	9.14 ± 1.03			0.62 ± 0.11[b]				280 ± 80[c]	GPS
Krustrup et al. [12]	2008	12	International	Scandinavian	10.0 ± 0.5			1.6 ± 0.4					Video tape
		12	Domestic league	Scandinavian	9.7 ± 0.6			1.4 ± 04					Video tape
Mohr et al. [14]	2008	19	Highest division	All-USA pro league	10.33 ± 0.15	1379 ± 34	154 ± 7	1.68 ± 0.09	6.0 ± 0.3	1.2 ± 0.1	460 ± 20	30 ± 2	Video tape
		15	Domestic league	Scandinavian	10.44 ± 0.15	1326 ± 24	125 ± 7	1.3 ± 0.10	4.4 ± 0.5	0.9 ± 0.1	380 ± 50	26 ± 1	Video tape
Krustrup et al. [18]	2005	14	Highest division	Danish	10.3	1459	125	1.31			160	26	Video tape

Data are mean ± standard deviation

GPS global positioning system

[a] Descriptive definition

[b] >16 km·h^{-1}

[c] >20 km·h^{-1}

distances at high-intensities (1,260m) compared midfield (1,650m) and attackers (1,630m) while attackers accumulated the greatest amount of sprint distances (520m), with midfielders sprinting 430m and defenders sprinting 330m.

Congruent with previous observations, Andersson et al. (2010) examined the match demands of Scandinavian international players using time-motion analysis, to quantify locomotor activities during 1-3 international matches in players played the same outfield position. In total, 17 players (9 defenders, 5 midfielders, and 3 forwards) were involved, resulting in 54 matches being included in the analysis. 10 players were recorded in only a single match while 7 were recorded in 2-3 matches. matches being retrospectively analyzed using video analysis and computer coding. Unlike the work of Datson (2017) and Mohr (2008), international matches included both matches with an individual player's national team or UEFA Cup matches in which domestic league teams compete in against other European teams. Similar to the findings of others, Andersson et al. (2010) found that amongst 3 position classification: defenders, midfielders and forwards, midfield players have the greatest physical outputs during match play, followed in linear fashion by forwards and then defenders, who ran the least in total distance and distance at high-intensities. Total distance covered by position groups were 10,600m, 9,800m and 9,500m respectively. As a result, Scandinavian international players averaged 9,900m of total distance. Of the total distances covered, players had a mean high-intensity running distance of 1,530m (> 15 km/h) and sprint distance of 256m (> 25 km/h). Similar to the findings of Mohr et al., (2008), Andersson (2010) observed midfielders covered more high-intensity running distance (1,900m) compared to defenders (1,300m) and forwards (1,650m). Sprint distance, it was found, did not differ statistically amongst position groups.

More recently, Ramos et al. (2018) observed the match demands of 17 Brazilian international players during 6 matches at the 2016 Olympic Games. Player data was collected using player mounted GPS units (Catapult Sports, Australia) sampling at 10 Hz. Velocity thresholds in this study were set substantially higher than previous observation with high-speed running being 15.6-20 km/h and sprinting to be > 20 km/h. As a result, high-speed running and sprint values vary in comparison to those previously discussed. In their analysis, Ramos and colleagues examined 4 position categories, rather than the more traditional three, separating defenders into fullbacks and central defenders. In their investigation, it was found that forwards covered the least amount of total distance in comparison to the other 3 positional categories with midfielders covering the greatest distance at 10,376m, followed by fullbacks at 10,237m and central defenders 10,003m. These volumes of total distances are greater than those observed in by Mohr (2008), Hewitt (2014), Andersson (2010). This might be explained by the importance of the competition as data was collected during the Olympic Games, which is a major international competition, compared to international friendly matches which are likely to lack the same competitive nature. Ramos et al. (2018) identified the high-speed running demands to range between 590-840m depending on positions with fullbacks covering the most high-speed distance at 840m, while midfielders, forwards and central defenders covered 810m, 782m, and 590m respectively. Sprint distances found by Ramos and colleagues were similar to those reported by Hewitt (2014) and Datson (2017) with fullbacks attaining the highest volume at 379m. Forward players were slightly lower compared to fullbacks with 351m, followed by midfield players at 298m and central defenders significantly lower at 198m.

Professional Level. Women's soccer has been more extensively studies at the professional level in comparison to international level or collegiate level soccer. In 2005, Krustrup et al. observed 14 professional players from the first division in Denmark. Players were grouped into positions as defenders, midfielders, or forward. Matches were video recorded and retrospectively analyzed using computer coding. Each player was observed in a single match, all within a 3-week period. For analysis, high-speed running threshold was set at 18-25 km/h (Bangsbo, 1991) and sprint threshold was set at > 25km/h. In their findings, Krustrup and colleague determined female player in the Danish first division covered an average total distance of 10,300m, ranging between 9,700-11,300m during match play. Regarding high-intensity running and sprinting, it was found that players ran an average 1,310m at high-intensities (710-1,700m) while sprinting 160m (50-280m).

Mohr et al. (2008) examined the activity profiles of international level and professional level women's soccer players. A sample of 19 international level players from 9 different countries and 15 professional level players from two different professional leagues were videotaped in one or two matches and analyzed using video analysis using computerized coding of activity pattern. It was found that there was not a statistically significant difference in total distance covered between international level and professional level players. International level players ran an average of 10,330m whereas professional level players averaged greater total distance of 10,440m per match. These findings suggest that total distance covered during a 90-minute match may vary by a non-statistically significant amount, at least, between professional and international level players. Alternatively, there does appear to be a statistical difference in high-intensity running and sprint distance, which may be distinguishing factors in players ability to play at the international level. According to the findings of Mohr et al. (2008) international

level players covered 1,680m and 460m of high-intensity running and sprint distance, respectively. Professional level players on the other hands only ran 1,300m of high-intensity distance with 380m of sprinting. Based on these findings, it is likely reasonable to infer an enhanced ability to cover distance at both high-intensity and sprinting is required at of international level players in comparison to professional level players. Mohr et al. (2008) also distinguished between activity profiles for defender, midfielder, and forward groups finding that defenders covered the least amount of high-intensity and sprint distance at 1,260m and 330m in comparison to midfielders, who covered the most high-intensity distance at 1,650m and second most sprint distance of 430m, with forwards covering the greatest volume of sprint distance at 520m while running 1,630m of high-intensity distance.

Andersson et al. (2010) explored the difference in female player activity profiles in international compared to domestic league games. Players were video recorded in 1-3 matches with matches being retrospectively analyzed using computer coding. International matches included both matches with an individual players national team or UEFA Cup matches in which domestic league teams compete against other European teams. According to their findings, professional players in the Danish domestic league covered on average 9,700m per match, with 1,330m at high-intensities and 221m sprinting. In comparison to international level matches, total distance covered, high-intensity distance and sprint distance were all lower in comparison. Additionally, Andersson et al. (2010) examined 3 position classification; defenders, midfielders and forwards player to determine positional differences between groups. Midfield players demonstrated the greatest physical outputs during match play, covering 10,100m of total distance compared to 9,500m for both defenders and forwards. In similar fashion, midfield players also

had the highest volume of high-intensity running distance, however, had lower average sprint distance values compared to defenders, 230m compared to 221m.

Bradley et al. (2014) explored the match demands of female players at the professional level in Europe. Each of the player were video recorded during match play using a digital camera system. Following the matches, performances were analyzed using time-motion analysis software (Prozone Sports Ltd., Leeds, United Kingdom). Bradley and colleagues found professional European players ran an average of 10,800m during match play, ranging from 10,200m for central defenders to 11,100m for central midfielders. Also included in this study were the high-intensity running demands of different positions during competitive match play. High-intensity running distances ranged from 1,330m for central defenders to 1,910m for forward players, with all positions averaging 1,650m of high-intensity running distance. Based on these findings, European professional players cover a higher volume of total running distances during competitive matches compared to previous finding of Krustrup (2005), Mohr (2008), and Andersson (2010).

More recently, Bradley et al. (2015) observed professional women's players in the United States. Player data was collected using player mounted GPS units (SPI Pro, GPSport) sampling at 5 Hz. According to their findings, Bradley (2015) determined professional female players in the United States ran between 9,100-10,100m during competitive matches. Of this distance, players covered between 1,200-1,300m at high-intensity, however sprinting values were not provided. Similarly, in a study conducted by Datson et al. (2017), which observed 107 players across 13 teams overs 10 matches using a computerized semiautomated multicamera image recognition system (Prozone Sports Ltd., Leeds, United Kingdom) it was determined that professional players in Europe covered a total distance of 10,321m. These findings are consistent

with previous observation of professional European players Bradley et al. (2014) finding that professional players in Europe cover an average total distance of 10,754m. In another study conducted by Mara et al. (2017) which observed 12 elite female players from the Australian national league over 7 matches using an Optical Player Tracking system and found players covered an average total distance of 10,025m per game with central defender running the least (9,220m) and midfielders running the most (10,581m).

Collegiate Level. As pointed out by numerous researchers (Andersson, 2010; Bangsbo, 2014; Datson, 2014; Datson, 2017; Krustrup, 2005; Mohr, 2008; Vescovi, 2014), research objectifying the activity profiles of female players is scarce when compared to their male counterparts. Within the limited body of existing literature pertaining to female players, only a single study exists exploring activity profiles of female players at the division I college level. Vescovi et al. (2014) conducted an observational study designed to quantify the locomotor characteristics of female soccer players at the college level. 113 division I college soccer players from 9 universities were observed in a single match. Data was collected using player mounted GPS devices (SPI Pro, GPSports, Australia) sampling at 5 Hz to quantify total distance as well as high-intensity running and sprint distances. The velocity thresholds for high-speed running were set at 15.6-20 km/h and sprinting was classified as distance covered > 20 km/h. These velocity thresholds are higher than those used in other studies quantifying activity profiles for female player, which can result in lower volumes of running within each specified velocity classification. As such, Vescovi and colleagues observed that female players at the division I level average a total distance of 9,930m. Forwards ran the greatest total distance at 10,200m, followed by midfielder at 10,100m and with defenders running the lowest distances at 9,500m.

Potentially of greater importance, given its association to critical moments within matches, high-intensity running distance at the division I college level was averaged to be 813m. Once again, forward players were responsible for the greatest volume of high-intensity running distance at 929m, while midfield players ran somewhat less distance, 762m, at high-intensity and defender ran the least, covering only 748m. Interestingly, Vescovi et al. (2014) observed a higher volume of sprint distance for defenders in comparison to midfield players, 266m for defenders compared to 197m for midfielders. Forwards on the other hand, demonstrated the greatest output with regard to sprint distance, covering 339m.

In a study seeking to identify determinants of high-intensity running in collegiate women's during a soccer match, McCormack et al. (2014) observed 10 division I collegiate female soccer players during an inter-squad match during the NCAA spring season. Of the players observed, there were 5 midfielders, 4 forwards, and 1 wide defender. Athletes were fitted with player mounted GPS devices (Minimaxx 4.0, Catapult, Australia) sampling at 10 Hz. Although match format reflected that of a regular season match, it is highly likely that intensity and motivation present within a scrimmage during the non-competitive segment of the college season is wholly representative of a regular season competition. Considering monitoring and, given the limited data available on match demands of female college soccer, such information is indeed useful. Furthermore, according to their findings, female college players ran 8,950m during a 90-minute match with 1,580m being run at high-intensity (> 13 km/h). Unfortunately, McCormack and colleagues did not provide data regarding player sprint volumes.

At the time, perhaps the most in-depth exploration of female college soccer was provided by Alexander (2014, dissertation). Alexander (2014) observed 6 female division I collegiate players over an entire season, consisting of 17-matches. Data was collected using player

mounted GPS devices (Minimaxx 4.0, Catapult, Australia) sampling at 10 Hz. Of the 6 players, five positional categories were represented including central attacking midfielder, central defensive midfielder, central defender, fullback, outside midfielder, and forward. Despite a small sample of players, Alexander (2014) provides a greater depth of data given the number of matches observed which may provide a more representative sample of the activity profiles of female college soccer players from both a position independent and position dependent standpoint. Collectively, the average distance covered independent of position was 9,285m, with 1,020m being covered at high-speeds (>15 km/h) and 427m at sprint speeds (>18 km/h). In his exploration of position dependent physical demands, Alexander (2014) found the following: central defensive midfielders covered the most total distance at 9,950m, with forwards covering 9,690m, outside midfielders 9,500m, fullbacks 9,300m, central attacking midfielders 9,230m, and central defenders 8,040m. Furthermore, high-speed running volumes for each position were greatest for forwards at 1,410m, followed by fullbacks and outside midfielders at 1,320m and 1,200m respectively. On the lower end, central defensive midfielders, central attacking midfielders, and central defenders covered 840m, 740m, and 610m respectively. In regard to sprint distance covered for each position, Alexander (2014) found forwards accumulated the largest volume of sprint distance. Forwards were found to average 614m of sprint distance during matches. The next highest values for sprinting were for fullbacks and outside midfielders who sprinted 559m and 519m respectively. Central attack midfielders and central defenders sprinted the next most at 323m and 279m, with central defensive midfielders sprinting the least of all positions. The finding provided by Alexander (2014) offer valuable insight into the activity profiles of female players at the college level across an entire season.

Another unpublished dissertation (Grazer, 2015) which examined the relationship between in-game high-speed running performance and physical qualities in Division I women's collegiate soccer players provided further insight into the volumes of high-speed running required at the college level. Data was not provided for total distance or sprint distance. Grazer (2015) observed 32 female college soccer players over the span of 3-season and included only players participating in a minimum of 4, 90-minute matches. Data was collected using player mounted GPS devices (Minimaxx 4.0, Catapult, Australia) sampling at 10 Hz. Upon analysis, Grazer (2015) found female college players averaged 1,034m of high-speed running distance (>15 km/h). Additionally, position dependent high-speed running values were provided for forwards, outside midfielders, fullbacks, central attacking midfielders, central defensive midfielders, and central defenders (1,456m, 1,286m, 1,155m, 906m, 843m, and 738m). Uniquely, this information provides a relatively large sample size of both athletes and number of matches, in addition to including multiple seasons. Such a broad dataset will be useful in providing a more accurate depiction of high-speed running profiles of female soccer players at the collegiate level.

Additionally, soccer consists of various positions which require differing physical profiles, specifically regarding total distances, HIR distances, and sprint distance (Table 1.3). This being the case, this study will explore the different physical profiles of three outfield position categories; attackers, midfielders, and defenders. Through this research, we hope to provide a greater understanding of the specific physical demands of each of the three position categories to provide coaches and practitioners with more precise information which can be used for improved training prescription.

Table 1.3

Summary of the physical demands of women's soccer at various standards of play

Author	Country	Standard	TD (km)	HIR-HSR (km)	Sprint	Position	Collection Method	HIR-HSR Thresholds
Krustrup, 2005	Denmark	Professional	10.30	1.30	.163	All	Video, Computerized Coding	HIR = >15 km/h, Sprint = >25 km/h
Hewitt, 2014	Australia	International	9.10	2.4	.340	All	GPS, Unit information not reported	HIR = >12 km/h, Sprint = >19 km/h
			9.00			D		
			8.50			F		
			9.60			MF		
Andersson, 2008	Sweden/Norwary	Professional	9.9	1.53	.253	All	Video, Computerized Coding	HIR = >15 km/h, Sprint = >25 km/h
Mohr, 2008	Denmark/Sweden	Professional	10.44	1.3		All	Video, Computerized Coding	HIR = >15 km/h, Sprint = >25 km/h
	USA	Professional	10.33	1.68		All		
	Grouped	Professional	10.40	1.26		D		
	Grouped	Professional	10.40	1.63		F		
	Grouped	Professional	10.40	1.65		MF		
Andersson, 2010	Scandinavia	Professional	9.70	1.33		All	Video, Computerized Coding	HIR = >15 km/h, Sprint = >25 km/h
		International	9.90	1.53		All		
		Professional	9.50			D		
		International	9.50	1.30		D		
		Professional	10.10			MF		
		International	10.50	1.90		MF		
Alexander, 2014 (Dissertation)	USA	College	9.23	0.74	.324	AM	GPS, Minimaxx 4.0, Catapult Innovations, 10 Hz	HSR = >15 km/h, Sprint = >18 km/h
		College	8.04	0.61	.279	CD		
		College	9.95	0.84	.270	CDM		
		College	9.69	1.41	.614	ATT		
		College	9.30	1.32	.559	FB		
		College	9.50	1.20	.519	WM		
Bradley, 2014	Europe	Professional	10.8	1.65		All	Prozone, Digital Camera System	HSR = >14.4 km/h, Sprint = >25.1 km/h
		Professional	10.20	1.33		CD		
		Professional	11.10	1.72		CM		

		Professional	10.80	1.91		F		
		Professional	10.70	1.65		FB		
		Professional	10.90	1.87		WM		
McCormack, 2014	USA	College	8.95	1.58		All	GPS, Minimaxx 4.0, Catapult Innovations, 10 Hz	
Vescovi, 2014	USA	College	9.50	.748	.266	D	GPS, SPI Pro, GPSports, 5 Hz	HSR = >15.5 km/h Sprint = > 20km/h
			10.30	.929	.339	F		
			10.13	.762	.197	MF		
			9.93	.813	.267	All		
Vescovi, 2015	USA	Professional	9.10	1.20		All	GPS, SPI Pro, GPSports, 5 Hz	
			10.10	1.30		All		
Ramos, 2018	Brazil	International	10.01	.590	.199	CD	GPS, Minimaxx S5, Catapult Innovations, 10 Hz	HSR = 15.6-20 km/h, Sprint = >20 km/h
			10.24	.840	.379	FB		
			10.38	.811	.299	MD		
			9.83	.783	.352	FW		
		Youth International (U20)	8.20	.509	.113	CD	GPS, Minimaxx S5, Catapult Innovations, 10 Hz	HSR = 15.6-20 km/h, Sprint = >20 km/h
			9.07	.859	.331	FB		
			8.49	.552	.126	MD		
			9.06	.830	.323	FW		
		Youth International (U17)	7.90	.348	.139	CD	GPS, Minimaxx S5, Catapult Innovations, 10 Hz	HSR = 15.6-20 km/h, Sprint = >20 km/h
			8.57	.637	.283	FB		
			8.55	.434	.096	MD		
			8.06	.520	.248	FW		

Mara, 2017		Professional	10.03	2.452	0.615	Team	Optical player tracking (Video analysis)	HIR = 12.24.4-19.08 km/h, Sprint = >19.44 km/h
			9.66	2.420	0.841	CF		
			10.47	2.917	0.850	WM		
			10.58	2.761	0.484	MF		
			9.22	1.772	0.417	CD		
			10.20	2.569	0.680	FB		
Grazer, 2015 (Dissertation)	USA	College		1.034		Team	GPS, Minimaxx 4.0, Catapult Innovations, 10 Hz	HSR = >15 km/h, Sprint = >18 km/h
				0.906		AM		
				0.843		CDM		
				1.286		WM		
				1.155		FB		
				0.738		CD		
				1.456		Att		
Datson, 2017	Europe	International	10.32	2.520	0.168	All	ProZone Optical player tracking (Video analysis)	HIR = >14.4 km/h, Sprint = >25.1 km/h
			9.49	1.901	0.111	CD		
			10.25	2.540	0.163	WD		
			10.99	2.882	0.17	CM		
			10.62	2.785	0.22	WM		
			10.26	2.586	0.221	ATT		
Datson, 2014	Europe	Professional	10.00	1.700		All		HIR = > 15 km/h

Summary

Available literature regarding the match and specific training demands of female soccer remains scarce in comparison to the extensive research which has driven the physical development of the men's game for decades. More recently, increasing interest in women's soccer in the form of participation, funding, marketing, and fan interest in addition to the increasing availability and cost of monitoring technology such as time-motion analysis and GPS tracking have provided an environment in which supporting research/monitoring for female soccer at various levels has become increasingly common. As such, the understanding that female players, and resultantly, the female game is unique in its demands from the men's game. This information has provided coaches and sport scientists with the knowledge to more appropriately tailor training methods to meet the unique match demands of the female game and the level of competition. Nevertheless, research into women's soccer remains heavily skewed in favor of the international and professional level.

In summary, it appears the preponderance of evidence agrees with the finding of Mohr (2008) that the match demands of female soccer increase at higher standards of play. Although total distance does not appear to fluctuate greatly between the international and professional levels, it does appear to be somewhat lower in collegiate soccer in comparison. However, at the international level, the match demands with regards to both high-intensity running and sprinting have been demonstrated to be greater than that of the professional level and significantly greater than the college level. Additionally, across all levels, midfield players consistently cover more total distance and high-intensity distance while sprint distance showed to vary by study in favor of attackers or midfield players. In saying that, defenders typically were observed to have the lower physical demand across all studies and all variables. Given these finding, we can infer that

female players require specific training to match the differing physical demands based on standard of play and playing position. With this background, and the gross lack of objective data regarding women's soccer at the Division I college level, more research in this area is needed.

CHAPTER 3

THE PHYSICAL DEMANDS OF NCAA DVISION I WOMEN'S COLLEGE SOCCER

Title: The Physical Demands of NCAA Division I Women's College Soccer

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Abstract

Extensive research into women's soccer at the collegiate level has been scarce, leaving gaps in the literature and little information detailing the physical demands at different standards of play. The purpose of this study is to add to our understanding of the activity profiles of female soccer at the division I collegiate level, differences from higher standards of play and playing position. Twenty-three field players were monitored during 4 competitive seasons using 10-Hz GPS units (Catapult Sports, Australia). Descriptive statistics as well as 95% confidence intervals were used to infer differences from higher standards of play. Linear mixed modelling (LMM) was used to compare each position group at the collegiate level. Total distance, high-speed distance and sprint distance were 9,462 ± 721m, 1,030 ± 361m, and 435 ± 223m, respectively. Furthermore, attackers demonstrated the greatest physical demands compared to midfielders and defenders. Our findings have provided further evidence suggesting the physical demands of women's soccer at the division I level are lower for total distance, high-speed distance, and sprint distance compared to higher standards of play and differ by position group. Therefore, coaches and sports scientists responsible for the physical training of division I collegiate players should exercise a degree of caution when using published findings pertaining to activity profiles of higher-level players.

Introduction

Investigations concerning the physical demands of women's college soccer has spurred growing interest as the popularity of both soccer and women's sports have increased. However, even with a growing interest in sport science and performance, a thorough understanding of the physical demands of women's college soccer remains to be extensively explored. In general, research into women's soccer has been scarce (Reilly, Bangsbo, & Franks, 2000; Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005; Andersson et al., 2008; Andersson, Karlsen, Blomhoff, Raastad, &Kadi, 2010; Vescovi, 2012; Hewitt, Norton, & Lyons, 2014; Bradley, 2014; Bradley & Vescovi, 2015; Clarke, Anson, & Pyne, 2015; Hodun, Clarke, De Ste Croix, & Hughes, 2016; Datson et al., 2016; Mara, Thompson, Pumpa, & Morgan, 2017), leaving gaps in the literature regarding depth and breadth of information detailing the physical demands at different standards of play, particularly at the collegiate level (Vescovi, 2014). In addition, many of the studies to date which have been published have been completed using small sample sizes with regard to number of players, number of matches, or both (Mohr, 2008; Andersson, 2010; McCormack, 2014; Hewitt, 2014; Datson, 2017). This being the case, further investigations into the physical demands of women's soccer are warranted.

There is a disproportionate amount of literature relating to male players in comparison to female players. This is largely due to the cost associated with tracking and monitoring technology, which is often limited to professional men's teams (Mara et al., 2017). Though many aspects of men's and women's soccer are the same, such as pitch dimensions, match duration, number of players, goal size, and ball size, males and females can differ dramatically with regard to physical performance characteristics, with male players performing 30% more high-intensity activity during matches (Mohr, 2008) and demonstrating superior performance across a range of

fitness assessments (Mujika, Santisteban, Impellizzeri, & Castagna, 2009; Mujika, Spencer, Santisteban, Goiriena, & Bishop, 2009; Tønnessen, Hem, Leirstein, Haugen, & Seiler, 2013). As a result, research finding from observations of male player may not accurately reflect the physical demands of female players. There has been literature detailing physical demands of women's soccer at the professional and international levels in which players have been observed to cover approximately 10,000m per match, during which they perform between 70 – 190 high-intensity actions resulting in high-intensity distances ranging from 1,530 – 1,680m and sprinting between 380 – 460m (Mohr et al., 2008; Andersson et al., 2010; Datson, 2014). Considering that HIR and sprinting efforts, as well as distance covered, increase with the standard of play, it can be hypothesized that the activity profiles of women's college soccer deviate from those found at the professional and international standard of play. Vescovi et al. (2014) were the first, and to our knowledge, only published study to report on the locomotor characteristics of division I women's college soccer matches finding players covered a mean total distance of 9,930m with 1,080m at high-speed (> 15.5 km/h) and 267m sprinting (> 20 km/h). Considering much of the current literature objectifying activity profiles for women's soccer have been investigations of professional and international level players (Bangsbo, 2006; Mohr, 2008; Bradley, 2009; Andersson, 2010; Ramos, 2017) and with scant evidence existing to detail the physical demands of women's soccer at the collegiate level, further investigation into this specific area of research is needed. Therefore, the purpose of this study is to add to our understanding of the activity profiles of female soccer at the division I collegiate level, differences from higher standards of play and between playing positions, which is necessary for coaches and sports scientists to more appropriately prescribe training to maximize performance and minimize injury risks.

Methods

Experimental approach to the Problem

For our study, we observed the match demands of women's collegiate soccer players over four consecutive seasons to determine the physical demands associated with the division I college level. Furthermore, playing positions were used to identify differing match requirements between defenders, midfielders, and attacking players. Global Positioning System (GPS) devices (Catapult Sports, Melbourne, Australia) sampling at 10 Hz were used to track player movements during competition. Units were secured to subjects using custom designed harnesses placing the GPS monitor on the upper-back between the shoulder blades. In accordance with previous investigations of female soccer players, velocity thresholds used to categorize player movements were: standing (0-0.1 km/h), walking (0.1-6.0 km/h), jogging (6.1-8.0 km/h), low-speed running (8.1-12.0 km/h), moderate-speed running (12.1-15.0 km/h), high-speed running (15.1-18.0 km/h), sprinting (18.1-25.0 km/h), and max sprinting (> 25 km/h) (Krustrup et al., 2005, Andersson et al., 2010, Alexander (Dissertation), 2014). Having been previously established as physical variables associated with match performance, total distance, high-speed running distance (> 15 km/h) and sprint distances (> 18 km/h) were chosen to be analyzed (Krustrup et al., 2003, Krustrup et al., 2005, Andersson et al., 2010, Alexander (Dissertation), 2014).

Subjects and Match Analysis

Over the span of four seasons, twenty-three female college players with a mean age (years): 20.6 ± 1.0, body mass (kg): 62.1 ± 7.1, height (cm): 163.5 ± 13.3, and body fat (%): 22.4 ± 5.4 were observed providing 375 match observations. Matches were only included if players

participated in the match in its entirety, without substitution. Additionally, all matches were contested in the U.S., on pitches meeting the established NCAA regulation with regard to field dimensions. In accordance with NCAA rules, matches consisted of two 45-minutes halves separated by a 15-minute half time period. In the event of a tie, two, 10-minute, golden goal, extra time periods separated by a 2-minute intermission are played. Players were categorized into one of three position groups for analysis: defenders, midfielders, or attackers. After collection, player data was downloaded and analyzed using manufactures proprietary software (Catapult OpenField & Catapult Sprint, Melbourne, Australia).

Match Activities

In our investigation we will focus our attention on variables which objectify the physical demands of soccer match play, specifically total distance covered, high-speed distance and sprint distance. In doing so, we narrow our investigation to the most pertinent variables affecting match outcomes as well as those which are most easily understood by coaches and commonly explored by researchers. Within the current literature, there exists ample support for our focus on total distance, high-speed running distance and sprint distance. Quantifying total distance provides an estimate of total running volume, additionally, it has historically been one of the most common variables studied (Cummins, 2013). According to Bangsbo (2014), although the majority of distance is covered at low-speeds, periods of high intensity running are crucial to the outcomes of football matches by directly impacting goal-scoring opportunities (Datson, 2017). Additionally, the amount of high-speed running distinguishes top-class players from those at lower levels (Reilly et al., 2000; Krustrup et al., 2005; Hewitt et al., 2014), with top-class players covered 28% and 58% more high-speed running and sprint distances respectively (Mohr, 2003).

Statistical Analysis

The statistical software R (version 3.5.1) was used for all analyses. Linear mixed models fitted with maximum likelihood estimation were constructed for each dependent variable (total distance, HSR distance, and sprint distance) using the lme4 package (version 1.1-20) (Juhari, 2017; Sams, 2017). Player position was treated as a fixed effect, while matches and athletes were included as crossed random intercept effects. The emmeans package (version 1.3.3) was used to compute both overall and position-specific means and to perform post hoc pairwise comparisons between positions; the resultant pairwise comparisons' t ratios were used to calculate Cohen's d effect sizes via the psych package (version 1.8.12) (Rosenthal, 1991). Statistical significance was set at $p <= 0.05$. Effect size magnitudes are described according to Hopkins (2002): < 0.2 = trivial, 0.2 - 0.6 = small, 0.6 - 1.2 = moderate, and 1.2 - 2.0 = large. Data are presented as the estimate and associated 95% confidence interval.

Results

General Physical Demands

Total distance covered by the sample at the division I level, independent of playing position was observed to be 9,486 ± 300 (Table 2.1). Of that distance, the women's players averaged 1,014 ± 118m of high-speed running distance (>15 km/hr) per match, accounting for approximately 10.7% of match distance covered at high-speeds. Sprint distance values (> 18 km/hr), independent of playing position were observed to be 428 ± 70m. Sprint distance represented 4.5% of total match distance and 42% of all high-speed running distance.

Table 2.1. *General physical demands of division I women's soccer*

Variables	Mean ± SD (m)	95% CI (m)	Velocity Threshold
TD	9,486 ± 300	9,186 – 9,786	
HSRD	1,014 ± 118	895 – 1,132	>15 km/hr
SPRTD	428 ± 70	359 - 498	>18 km/hr

TD, Total distance; HSRD, High-speed running distance; SPRTD, Sprint distance; 95% CI, 95% Confidence Interval

Position Specific Physical Demands

No statistically significant differences were observed for total distance covered between position groups for attackers and midfielders or between midfielders and defenders ($p \leq 0.05$; Table 2.2). Values for total match distance covered by attackers were significantly greater than defenders (1,333m [p = 0.045], ES = 0.39 [-0.38 – 1.15], small). No significant differences were observed for total distance covered between Attacker and Midfielder positions or between Defender and Midfielder positions. Similarly, Attacker position covered significantly more high-speed running distance compared other position groups (Attacker-Midfielder: 493m [p = 0.0035], ES = 1.38 [0.53 – 2.22], large; Attacker-Defender: 465m [p = 0.0047], ES = 1.40 [0.51 – 2.27], large). No differences were observed for high-speed running distance between the Midfield and Defender position groups. Sprint distances values were observed to be statistically significant for Attackers compared to Midfielder positions (Attacker-Midfielder: 367m [p = 0.003], ES = 1.73 [0.84 – 2.61], large) as well as for Attackers compared to Defender position (Attacker-Defender: 249m [p = 0.01], ES = 1.27 [0.40 – 2.12], large). No statistically significant difference was found between Midfield and Defender positions for sprint distance.

Table 2.2. *Position dependent physical demands of Division I women's soccer*

Variable	Attacker	Midfielder	Defender	Comparison*
TD	9,882 (9,414 – 10,349)	9,536 (8,998 – 10,034)	9,039 (8,527 - 9,551)	A>D; A=M; M=D
HSRD	1,333 (1,147 - 1,519)	840 (626 - 1,054)	868 (665 - 1,071)	A>D,M; M=D
SPRTD	633 (524 - 743)	267 (141 - 393)	385 (265 - 504)	A>D,M; M=D

Values presented as means (95% CI), m; TD, Total distance; HSRD, High-speed running distance; SPRTD, Sprint distance

*>, statistically significant difference; =, non-statistically significant difference

Discussion

The purpose of this study was to provide a more thorough understanding of the activity profiles of female soccer at the division I collegiate level and observe differences in positional demands and compared to higher standards of competition. Such information may provide evidence for coaches and sports scientists to more specifically target physical training to meet the demands of women's collegiate soccer and the unique positional demands for attackers, midfielders, and defenders.

Our findings support the likelihood that the physical demands on women's soccer players at the division I collegiate level differ in comparison to those of professional and international standards of play. These findings agree with those of Mohr (2008) that physical demands are specific to the standard of play, with higher standards of play typically requiring greater physical outputs (Figure 2.2). Total distance covered at the division I collegiate level differs from International level. A total distance of 9,486m (9,186 – 9,786m) covered by college females appears lower than international and professional players from Norway, Sweden, Denmark, Brazil, Australia, USA, and other European countries which ranged from 9,630 – 10,750m (Krustrup, 2005; Mohr, 2008; Andersson, 2010; Bradley, 2014; Datson, 2014; Hewitt, 2014; Datson, 2017; Mara, 2017; Ramos, 2018). As a result, we can speculate that the lower physical

demands of women's soccer at the collegiate level are likely inadequate to prepare players for international competition.

Similarly, the match demands for high-speed running, 1,014m (895 – 1,132m), and sprinting, 428m (359 – 498m) were demonstrated to be less for college women at the division I level compared to both professional and international level players (Figure 2.3). Although various measurement techniques have been used and velocity thresholds are highly inconsistent with regard to determining entry into high-speed running and sprinting zones, high-speed running and sprint volumes appear to be greater in professional and international level matches. Krustrup (2005), Mohr (2008), Andersson (2010), and Bradley (2014) found international and profession players to cover 1,300 – 1,680m of high-intensity distances.

Regarding sprint distance, it can be inferred that players at higher standards of play accumulate substantially higher sprint volumes. Given that our sprinting threshold has been set at >18 km/hr, Mohr (2008) observed professional and international players to sprint 380m and 460m, respectively when sprint thresholds were set at >25 km/hr. Such is also the case in a study by Andersson (2010) which observed Scandinavian players to cover 221-256m above the 25 km/hr threshold. Given this evidence, it is reasonable to infer sprint distances would have been much greater had velocity thresholds for sprinting been >18 rather than > 25 km/hr.

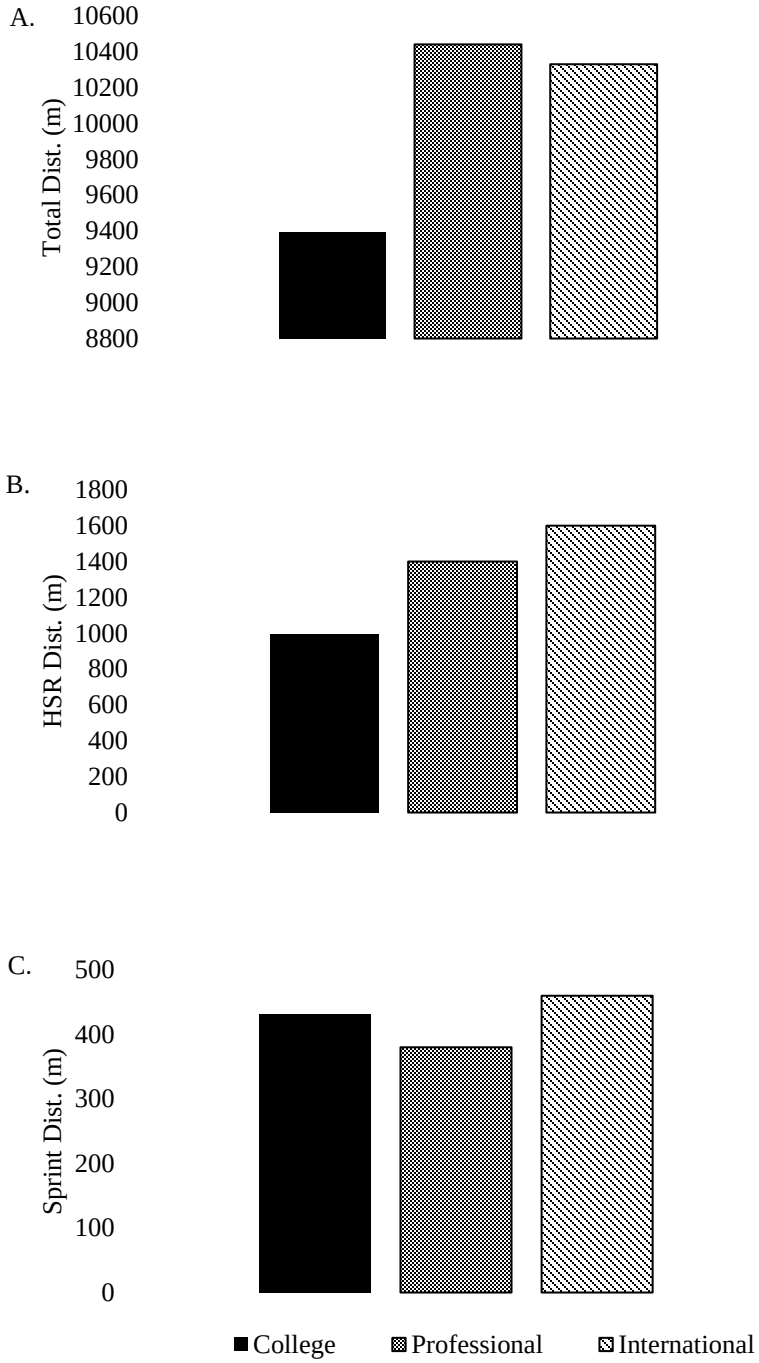

Figure 2.1. Comparison of current study findings for activity profiles in division I women's collegiate soccer to the finding of Mohr (2008) for professional and international level players. A.) total distance covered, B.) high-speed running distance, C.) sprint running distance. (adapted from Mohr, 2008).

High-intensity demands are particularly important for collegiate players also serving as members of their respective national teams. Unlike men's soccer, it is common for international level players to also participate in division I collegiate soccer. Players in such a role are often required to participate in national team camps and matches during the college season. These call-ups can expose players to acute spikes in high-intensity demands at the international level (Vescovi, 2014). With this understanding, our data along with that of others (Vescovi, 2014) suggests structuring training to develop greater capacities for high-intensity work through increased volumes of high-speed running and sprinting. As such, having an objective understanding of the differing physical demands between standards of play can provide useful information to ensure such players are supplemented with the appropriate volume and intensity of training required to bridge the performance gap between the collegiate and international level.

Positional differences have been found to exist at all standards of play between attackers, midfielders and defenders. Traditionally, midfield players have been found to cover the greatest amount of total distance per match compared to attackers and defenders at the professional and international level (Krustrup, 2005; Mohr, 2008; Andersson, 2010). In contrast, the findings of the current study observed attackers to cover the greatest volume of total distance, as well as high intensity distance. Interestingly, Vescovi (2014) reported similar findings for division I college females with attackers covering the greatest total distance and high-intensity distance, although values for each variable were found to be higher for each position group compared to our results. This may be indicative of differing team tactical demands or collegiate soccer demands compared to professional and international standard of play. Nevertheless, although defenders, midfielders, and attackers exhibited similarities in position specific physical demands, distinct differences were observed between each of the three positional categories which can be

used as a means for sport scientists and coaches to provide more specific training based on playing position.

It has been demonstrated that the physical demands of women's soccer increase in a linear fashion as the standard of play advances from youth to college and beyond college to professional and international levels (Krustrup, 2005; Mohr, 2008; Andersson, 2010; Vescovi, 2014). Due to these differences, coaches must consider the training history and physical capacity of their players. In general, players in the collegiate realm will not possess the same physical capacities as more elite players whom progress to the professional and international level. Therefore, logic (and physiology) would suggest that it is inappropriate for collegiate players to be subjected to workloads suited for more elite players at higher levels. Such exposure to high workloads has the real possibility to expose athletes to non-functional overreaching or overtraining (Cunanan, 2018), increasing the risk of overuse injuries (Gabbett, 2011). As a result, the addition of objective evidence to better understand the physical demands of women's collegiate soccer at the division I level to support the findings of Vescovi (2014) and McCormak (2014) are needed.

Conclusion

This study is the explored the physical demands of women's soccer at the Division I level and the differences between competitive standards and positions. Like Vescovi (2014) who observed players from 9 NCAA institutions in single matches and did not require full-match participation, we observed the physical demands for 23 athletes across 4-consectutive season, for which only full-match participation was required. Our findings provide objective data regarding the general and position specific physical demands of women's college soccer at the Division I level and can be useful for coaches and sport scientist to consider when constructing training and

conditioning programs. Additionally, we have provided further evidence suggesting the physical demands of women's soccer at the Division I level are lower for total distance, high-speed distance, and sprint distance compared to higher standards of play and differ by position group between attackers, midfielders and defenders. Therefore, coaches and sports scientists responsible for the physical training of Division I collegiate players must exercise a degree of caution when using published findings pertaining to activity profiles of professional and international level players as benchmarks for their sub-elite athletes.

Some limitations to the present study include the use of a single Division I college women's team. Although data was collected over the span of 4-seasons, it may not be fully representative of all Division I women's soccer teams. Additionally, consideration must be given to player turnover and its effect on team composition, tactical strategy, and physical demands. Having more talented attacking players and a resulting attacking tactical philosophy in one season compared to more talented defenders and a resulting defensive tactical philosophy has the potential to skew seasonal data as it has been established that attackers have increased physical outputs compared to defenders.

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CHAPTER 4

CHANGES IN THE PHYSICAL DEMANDS OF DIVISION I WOMEN'S COLLEGE SOCCER PLAYERS OVER A FOUR-YEAR CAREER: A CASE STUDY

Title: Changes in the Physical Demands of Division I Women's College Soccer Players over a Four-Year Career: A case Study

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Abstract

Investigations of the physical demands of women's college soccer have garnered growing interest as the popularity of both soccer and women's sports have increased. Even with a growing interest in sport science, a thorough understanding of the physical demands of women's college soccer remains to be extensively explored. Therefore, the purpose of this case study is to examine seasonal changes in physical demands in women's college soccer. The seasonal variation in physical demands of two women's collegiate soccer players, spanning a four-year career were examined using Global Positioning System (GPS) devices sampling at 10 Hz. Descriptive statistics were age: 19-22, body mass (kg): 60.7 ± 3.6, height (cm): 167.9 ± 3.0, and body fat (%): 23.5 ± 5.2. Non-parametric Tau-U analysis was used to determine differences between each competitive season. In accordance with the findings of Gregson (2010), our finding demonstrated that physical demands of women's soccer at the NCAA Division I level fluctuate from season to season. Factors such as tactical formation, adoption of attacking versus defending strategy, match situations, home or away competition, and quality of opposition contribute to variation in physical demands of match play (Gregson, 2010; Bradley, 2011a; Castellano, Blanco-Villasenor, & Alvarez, 2011).

Introduction

Although it has been regarded as the world's most popular sport for decades, only recently has soccer begun to grow in popularity in the United States. With its blossoming popularity, participation in soccer has grown exponentially in the last 15-20 years. Such growth has increased playing opportunities at the youth, college, and professional level – from which, the most talented players are selected to represent their national teams at the highest standard of play, the international level. Unfortunately, research exploring women's soccer has been scarce, leaving gaps in the literature regarding depth and breadth of information detailing the physical demands at different standards of play. The few studies to date which have been published, have used small sample sizes with regard to number of players, number of matches, or both (Datson, 2017). Considering these problems, if we are able to elucidate the physical characteristics of competition, better training methods can be employed by coaches and practitioners resulting in improved performances by players.

Investigations of the physical demands of women's college soccer have garnered growing interest as the popularity of both soccer and women's sports have increased. However, although interest in the women's game has grown, as has the investment in sport science and performance, a thorough understanding of the physical demands of women's college soccer remains to be extensively explored. Vescovi et al. (2014) were the first to report on the locomotor characteristics of college female soccer matches, and ultimately a better understanding of the developmental spectrum from youth up to the international level. Much of the current literature objectifying activity profiles for soccer have been investigations of professional and international level players (Bangsbo, 2006; Bradley, 2009; Andersson, 2010; Ramos, 2017). Additionally, there is a disproportionate amount of literature relating to male players in comparison to female

players (Krustrup, 2005; Mohr, 2008). This is largely due to the cost associated with tracking and monitoring technology, which is often limited to professional men's teams (Mara et al., 2017). Men's and women's soccer share many similarities including pitch size, laws of the game, and number of players. However, despite many variables of match play being the same, males and females can differ dramatically with regard to physical performance characteristics. This is supported by Mohr (2008) who examined male and female players at the professional and international level. Their finds suggested that men and women at similar standards of play cover similar total match distance, with men performing a greater volume of high-speed running (≥ 18 km/hr) and sprinting (≥ 25 km/hr) (Abt, 2009). However, it has been proposed by Bradley and Vescovi (2015) that adapting velocity thresholds to more appropriately reflect the physical capacities of women's may result in a similar volume of high-speed running and sprinting compared to their male counter parts. It has also been found that higher standards of competition require greater volumes of high-speed running and sprinting compared to lower levels (Mohr, 2008; Vescovi & Favero, 2014; Andersson, 2010). As a result of this, the use of activity profiles from female players at the professional and international level to guide training prescription of female players at the division I college level may be inappropriate.

Physical Demands

Research investigating women's college soccer is scarce. At the time of Vescovi's observation, only one other study relating to the activity profiles of women's college soccer players. Although there has been literature detailing physical demands of women's soccer at the professional and international levels (Andersson et al., 2010, Mohr et al., 2008), considering that HSR and sprinting efforts, as well as distance covered, increase with the standard of play, it can

be hypothesized that the activity profiles of women's collegiate players likely differ from those found at the professional and international standard of play. More recently, Curtis et al. (2018) investigated men's college soccer players and found players covered a mean total distance of 8,900–9,900m per match with 1,300–1,900m of those at high-speed. Upon comparison, this is less than previously reported data reported for professional players which average 10–14 km of total distance (Bangsbo, 2006) and 2,700 m of high-speed running distance (Bradley, 2010). These findings are in agreement with previous literature in finding higher standards of play require greater physical outputs in regard to total distance covered, high-speed distance and sprint distance. This is in alignment with the findings of Alexander (2014) who determined that the physical demand of the game differs based on, among other things, playing position, team tactics, level of competition, and gender. Considering the little information available detailing the physical demands of women's soccer at the collegiate level, further investigation into this specific area of research is needed. Therefore, the purpose of this case study is to examine the physical demands of two, elite level, collegiate women's soccer players during a 4-year career. Our purpose is to provide a more thorough understanding of the changes in activity profiles of female soccer at the division I level during their collegiate career.

Methods

Experimental approach to the Problem

We examined the seasonal variation in activity profiles of two elite women's collegiate soccer players, spanning a four-year career from freshman to senior season. Global Positioning System (GPS) devices (Catapult Sports, Melbourne, Australia) sampling at 10 Hz were used to track player movements during competition. Units were secured to subjects using custom

designed harnesses placing the GPS monitor on the upper-back between the shoulder blades. Having been previously established as physical variables associated with match performance, total distance, high-speed running distance (>15 km/h) and sprint distances (> 18 km/h) were analyzed (Krustrup et al., 2003, Krustrup et al., 2005, Andersson et al., 2010, Bradley et al., 2013a, Bradley et al., 2013b, Bradley et al., 2014). After collection, player data was downloaded and analyzed using manufactures proprietary software (Catapult OpenField & Catapult Sprint, Melbourne, Australia).

Subjects and Match Analysis

Over the span of a four-year collegiate career, two female college soccer players, who had both represented their respective national teams at various levels were observed. For Athlete A and Athlete B, age range was 19-22 years, mean body mass (kg) of 63.9 ± 1.2 and 57.5 ± 0.4, height (cm) of 170.6 ± 0.5 and 165.3 ± 0.8, and body fat (%) 27.6 ± 3.3 and 19.4 ± 2.5, respectively. Match inclusion criteria consisted of full match participation, without substitution. All matches were contested in the U.S., on fields in accordance with established NCAA regulations regarding field dimensions and surface. Matches were played according to NCAA standards, consisting of two 45-minutes halves separated by a 15-minute half time period. In the event of a tie, two, 10-minute, golden goal, extra time periods were played with a 2-minute intermission.

Match Activities

In our investigation we focused our attention on variables which objectify the physical demands of soccer match play, specifically total distance covered, high-speed distance and sprint

distance. In accordance with previous investigations of female soccer players, velocity thresholds used to categorize player movements were: standing (0-0.1 km/h), walking (0.1-6.0 km/h), jogging (6.1-8.0 km/h), low-speed running (8.1-12.0 km/h), moderate-speed running (12.1-15.0 km/h), high-speed running (15.1-18.0 km/h), sprinting (18.1-25.0 km/h), and max sprinting (> 25 km/h) (Krustrup, 2003; Krustrup et al., 2005; Andersson et al., 2010; Alexander (Dissertation), 2014). In doing so, we narrow our investigation to the most pertinent variables affecting match outcomes as well as those which are most easily understood by coaches and commonly explored by researchers. Within the current literature, there exists ample support for our focus on total distance, high-speed running distance and sprint distance. Quantifying total distance provides an estimate of total volume, additionally, it has historically been one of the most common variables studied (Cummins, 2013). According to Bangsbo (2014), although the majority of distance is covered at low-speeds, periods of high intensity running are crucial to the outcomes of football matches by directly impacting goal-scoring opportunities (Datson, 2017). Additionally, the amount of high-speed running distinguishes top-class players from those at lower levels (Reilly et al., 2000; Krustrup et al., 2005; Hewitt et al., 2014), with top-class players covered 28% and 58% more high-speed running and sprint distances respectively (Mohr, 2003).

Statistical Analysis

For this study, data was collected over four seasons at the division I collegiate level. During this time, 2 division I female collegiate soccer outfield players were observed. Descriptive statistics outlining subject body mass, height, and body fat percentage were included. Both athletes were outfield players classified as defenders, (fullbacks). In total, 48 and 33 match

samples were compiled for Athlete A and Athlete B, respectively. For inclusion, subjects were required to have completed the entire match without substitution.

Descriptive statistics were used to elucidate the general physical demands of match play in each season with regard to total distance covered, high-speed running distance, and sprint distance. For between season comparison, in accordance with the methods of Alexander (2014), non-parametric Tau-U analysis was used to determine differences between each variable over each competitive season. Tau-U is a non-parametric method for measuring data nonoverlap between two phases (Parker, 2011). Phase contrasts were carried out to determine between season effects. To account for each season, the P-value was adjusted for significance ($p \leq 0.05$). Effect sizes between seasons were reported.

Results

Athlete A

Athlete A, participated in 48 complete matches in her collegiate career, during which she covered an average total distance of 9,307 ± 208m during her career (Table 3.1). No seasons were determined to be statistically different for total distance covered (Table 3.2). The greatest volume of total distance was covered during her sophomore season. Comparatively, athlete A covered the lowest total distance per match in her freshman season, followed by her senior season. When averaged across all seasons, high-speed running distance was found to be 1,095 ± 113m, with statistical significance being found between Sophomore-Senior ($p = 0.0017$) season. According to individual seasons, the greatest sprint volume during athlete A's career was experienced during her junior year, covering 1,188 ± 363m above 15 km/hr. High-speed running values were next highest during her sophomore year, followed by athlete A's freshman year.

Athlete A's high-speed running values were lowest during her senior year, covering 1,095 ± 113m. Sprinting values were greatest in athlete A's sophomore season when she averaged 563 ± 165m of sprint volume, compared to her junior season when 546 ± 203m of sprint distance was covered. Alternatively, the lowest volume of running produced by athlete A was during her senior season, when she sprinted only 442 ± 111m. Across all season, average sprint volume was 519 ± 54m. Statistical significance was found between Athlete A's Freshman-Senior ($p = 0.0415$) seasons and Sophomore-Senior ($p = 0.0032$) seasons.

Table 3.1. *Physical demands by season*

Subject	Variables	Freshman	Sophomore	Junior	Senior	Career
Athlete A	Matches	15	10	10	13	12
	TD (m)	9,072 ± 1,420	9,575 ± 394	9,327 ± 536	9,253 ± 586	9,307 ± 208
	HSRD (m)	1,064 ± 300	1,179 ± 319	1,188 ± 363	948 ± 178	1,095 ± 113
	SRPT (m)	523 ± 159	563 ± 165	546 ± 203	442 ± 111	519 ± 54
Athlete B	Matches	8	8	4	13	8.25
	TD (m)	9,147 ± 378	9,736 ± 570	9,933 ± 887	9,138 ± 585	9,488 ± 408
	HSRD (m)	1,202 ± 174	1,237 ± 345	1,123 ± 103	883 ± 67	1,114 ± 154
	SPRT (m)	550 ± 118	569 ± 241	507 ± 74	379 ± 102	501 ± 86

TD = Total Distance, HSRD = High-speed running distance, SPRT = Sprint running distance
*All values provided as mean ± standard deviations

Table 3.2. *Effect sizes (Athlete A)*

	Season	Freshman	Sophomore	Junior	Senior
Total Distance	Freshman	-			
	Sophomore	0.2571	-		
	Junior	-0.1429	-0.36	-	
	Senior	-0.1099	-0.4462	-0.0923	-
High-Speed Running Distance	Freshman	-			
	Sophomore	0.2714	-		
	Junior	0.0714	-0.3500	-	
	Senior	-0.3846	-0.7769*	-0.4	-
Sprint Distance	Freshman	-			
	Sophomore	0.1857	-		
	Junior	-0.1214	-0.43	-	
	Senior	-0.4615*	-0.7308*	-0.1769	-

* $p \leq 0.05$

Athlete B

In 33 career complete matches, Athlete B covered an average total distance of 9,488 ± 408m during her career. A statistical difference (Table 3.3) was found for total distance covered between sophomore-senior season ($p = 0.0091$). The greatest volume of total distance was covered during her junior season at 9,933 ± 887m per match. In descending order, total distance covered per season was observed to be sophomore, freshman, senior with 9,363 ± 1,238m, 9,936 ± 570m, and 9,138 ± 585m, respectively. High-speed running values were greatest during Athlete B's sophomore season, 1,237 ± 345m, and lowest during her senior season, 883 ± 67m. In her career, Athlete B produced a mean high-speed running distance of 1,114 ± 154m. Sprint values for Athlete B demonstrated a mean distance of 501 ± 86m, and were greatest during her sophomore season, 569 ± 242m. Differences in high-speed running distance were statistically significant between Freshman-Senior ($p = 0.0047$) season, Sophomore-Senior season (0.0169) and Junior-Senior ($p = 0.0174$) seasons. Sprint values were lower during freshman season, 550 ± 118m, and seen to decrease in subsequent years from 507 ± 74m to 379 ± 102m during junior and senior seasons. Statistical differences were present between Freshman-Senior ($p = 0.0047$) and Junior-Senior ($p = 0.0415$) seasons.

Table 3.3. *Effect sizes (Athlete B)*

	Season	Freshman	Sophomore	Junior	Senior
Total Distance	Freshman	-			
	Sophomore	0.5625	-		
	Junior	0.6875	-0.3125	-	
	Senior	0.0385	-0.6923*	-0.6538	-
High-Speed Running Distance	Freshman	-			
	Sophomore	-0.0625	-		
	Junior	-0.3438	0.0625	-	
	Senior	-0.8077*	-0.6346*	-0.8077*	-
Sprint Distance	Freshman	-			
	Sophomore	-0.0938	-		
	Junior	-0.1875	0.0625	-	
	Senior	-0.75*	-0.4615	-0.6923*	-

* $p \leq 0.05$

Discussion

The purpose of this case study was to examine the variation in physical demands of two women's collegiate soccer players during a college career. Research investigating the physical demands of women's soccer is substantially less in comparison to that of their male counterparts (Krustrup, 2005; Mohr, 2008). Previous research has been primarily focused on players at the professional and international level of play (Vescovi, 2014). More specifically, research elucidating the physical demands of NCAA Division I women's soccer is scarce. As such, this is the first study to examine the physical demands of women's soccer players at the NCAA Division I level across a 4-year career.

It may be rational to presume players physical performances subscribe to positive, linear trajectories from freshman to senior year. However, based on the finding of our case study, this may not be entirely accurate. Our results demonstrated statistically significant decreases in high-speed running for Athlete A between sophomore-senior and Athlete B between freshman-senior,

junior-senior season. Additionally, statistical differences were found in sprint distance for Athlete A between freshman-senior, sophomore-senior and Athlete B between freshman-senior, junior-senior. Also, of note, both athletes demonstrated seasonal variation, with the lower values for high-speed running and sprinting during their final season of play. Ours was not the first longitudinal study to identify seasonal variation in activity profiles. Gregson (2010) observed English Premier League players across 3 seasons, from which their data demonstrated decreases in total distance, high-speed running distance, and sprint distance. Due to its highly variable nature and the multitude of factors affecting high speed running performance, match HSR distance may not be an accurate or appropriate barometer for evaluating training interventions. Observed fluctuations in match performance may be attributable to a multitude of influential factors such as tactics, style of play, quality of opponent, pitch dimensions, pacing strategies, on match performance. Specifically, style of play (attacking or defensive), tactical formation (4-4-2, 4-3-3, 4-5-1), positional role and situational effect have been found to influence high-intensity match demands (Bradley, 2011, Bangsbo, 2014). Drawing from existing evidence, some of the observed variation in physical demands can likely be explained by deviations in factors such as team tactics, style of play, and positional role.

Bradley (2013a) and colleagues explored the extent to which professional players at different standards of play taxed their physical capacity during match play. Players from the three highest professional leagues in England were tested in the Yo-Yo intermittent endurance test level 2 (YYIR2) as a means of assessing physical capacity and tracked during match play using a multi-camera computerized tracking system (Prozone Sports Ltd®, Leeds, UK). Despite observing no difference between standards of play with regard to YYIR2 scores, they reported two interesting findings, 1.) due to the complexity of the relationship between physical capacity

and match performance, players with superior physical capacity may experience lower match demands as a result of tactical, situational, and/or positional constraints (Gregson, 2010; Bradley, 2011a; Castellano, Blanco-Villasenor, & Alvarez, 2011) and 2.) although no differences were observed in physical capacity between the top two standards of play (Premier League and Championship), players at the Championship level exhibited greater match outputs than Premier League players. Therefore, seasonal variation in physical demands found in our study may not necessarily be the result of decrements in fitness characteristics but rather alterations in factors such as style of play, tactical strategies, positional roles or situational match effects.

Another consideration for the variation in physical match demands exhibited by Athlete A and B in our study is technical ability of skill level. Although physical characteristics such as endurance, speed, and strength are important contributors to athletic performance (Stone, 2007), particularly at sub-elite levels, successful soccer performance is contingent on technical skill. Alternatively, given a greater homogeneity of physical characteristics at the professional and international levels, it is ultimately technical skill and tactical knowledge which will differentiate players between higher and lower standards of play (Barnes, 2014). This is illustrated by the findings of Bradley (2013a) that Premier league players perform lower volumes of high-intensity running than less talented players at the championship level as a result of better positioning, improved decision making, more accurate passing, and fewer changes in possession – all of which result in a reduction in the amount of transition running. This may, to some extent, explain the declining trend in high-intensity match demands for Athlete A and Athlete B in our study. Considering both players have competed at the international standard and can be considered high-level players at the collegiate level, higher tactical acumen and technical ability, coupled

with greater experience is likely to influence overall physical match demands, specifically high-intensity activities.

Limitations

The most notable limitation of our case study is the small sample size. Although match data from four-consecutive seasons were included, the physical match demands of two individuals may not be representative of other players, positions, or teams. Other limitations of the current study include the absence of physical testing data and specific tactical, situational, and strategic information. The inclusion of strength, speed power, and fitness testing data would allow for a more comprehensive understanding of changes in physical capacity and its relationship with match activity profiles. Additionally, specific tactical and situational information for each match such as playing formation, home or away competition, opponent ranking, weather conditions, and pitch dimension would provide useful information to more fully explain variations in match physical demands. Future studies should attempt to include these measures to better explain and more fully understand the match to match and seasonal variation of physical demands with regard to women's soccer at the NCAA Division I level.

Conclusion

The sport of soccer is highly complex with many factors contributing to both match outcomes and match physical performance. In accordance with the findings of Gregson (2010), our finding demonstrated that physical demands of women's soccer at the NCAA Division I level fluctuate from season to season. Factors such as tactical formation, adoption of attacking versus defending strategy, match situations, home or away competition, and quality of opposition

contribute to variation in physical demands of match play (Gregson, 2010; Bradley, 2011a; Castellano, Blanco-Villasenor, & Alvarez, 2011). Due to these factors and others, using activity profiles from competitive matches may not be an appropriate or accurate indicator for evaluating the effectiveness of a training intervention. Therefore, it is important for coaches and sports scientists to understand what factor influence physical demands in soccer for the purpose of optimizing the planning process and prescription of training. Finally, considering additional measures beyond match activity profiles, such as the YYIR2 or other fitness assessment, to evaluate changes in physical capacities is strongly advised.

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CHAPTER 5

SUMMARY AND FUTURE INVESTIGATIONS

The purpose of this dissertation was to examine the physical demands of NCAA Division I women's soccer. In doing so, the following investigations were undertaken: 1) an investigation of the physical demands of NCAA Division I women's college soccer, 2) a case study examining the seasonal variation in physical demands for two players across a four-year college career.

Based on our finding from study I, NCAA Division I women's soccer players appear to demonstrate lower physical demands compared to women's players at the professional and international standards of play, especially for high-intensity running. Additionally, in contrast to previous research, physical demands were also found to be greater for attacking players in comparison to midfield players and defenders, with defender position consistently requiring the lowest physical demands. These findings provide useful information for coaches and sport scientists at the collegiate level to more appropriately develop and prescribe training programs for their athletes. Understanding the specific physical demands associated with women's soccer at the NCAA Division I level may contribute to both enhancing athlete performance capabilities and the prevention of overuse injuries.

Study II explored the variation in physical demands of two division I women's soccer players during a four-year college career. Such information may be helpful for coaches and sport scientist to understand the factors affecting match performance and how they vary within and between seasons. Though our sample size consisted of two players, our investigation was unable to identify common trends in seasonal physical demands throughout the careers of two women's college players. However, both players examined were found to have lower match physical demands in their final season in comparison to previous seasons, possibly resulting from

increased technical skill and tactical awareness. Having said that, without the inclusion of more detailed tactical information and physical testing data, we can only speculate as to the mechanisms underlying seasonal variation.

As was the objective of this dissertation, adding data to the desolate landscape of women's soccer research is imperative for a more complete understanding of the spectrum of physical demands across various standards of play. Further research is needed to elucidate the varying physical demands of women's soccer player at all standards of play, particularly the NCAA Division I college level. Furthermore, more comprehensive examinations incorporating multiple teams, across various NCAA Division I conferences, over multiple seasons will provide a more holistic understanding of how physical demands at the collegiate level compare to the professional and international standard. Finally, supporting this research with physical testing data, tactical information and assessments of individual technical skill will add greater context to our understanding of factors contributing to or detracting from the physical demands and, ultimately, match performance.

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